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**(54) Signal Lamp, Especially Multichamber Signal Lamp for Motor Vehicles**

Known signal lamps working with light-emitting diodes do not make it possible to implement all signal colors, including white, employed in the motor vehicle sector.

It is proposed that three light-emitting diodes in the colors green, red, and blue be combined at each "point" in such a way that the light given off by them individually or jointly appears, with the aid of mixing optics, as a joint light source that makes it possible to implement all signal colors possible in the motor vehicle sector in dependence on the way in which the light-emitting diodes are wired up.

Use for motor vehicle lamps.

**Fig. 4**  
[see German original]

## Specification

This invention relates to a signal lamp, especially a multichamber signal lamp for motor vehicles, having light-emitting diodes or light-emitting diode chips as light source for generating at least two differently colored lamp functions and/or signal functions, on which voltage can be imposed separately or jointly as selected.

One such signal lamp is known from DE-PS 33 15 785 C2. This signal lamp employs three-phase light-emitting diodes that have a white or transparent appearance in the unexcited state and shine either red and yellow or red and green when voltage is imposed on them, depending on which anode lead had voltage imposed on it. In the known type, mixing colors can also be generated if both anodes are simultaneously supplied with voltage, so that for example the mixing color yellow arises from red and green.

Such three-phase light-emitting diodes or light-emitting diode chips are still relatively costly for use in motor vehicle signal lamps. Nor is it possible to generate a white light such as is needed for example for the backup light. For this, accordingly, a conventional lamp or, in the context of a multichamber lamp, a correspondingly fashioned chamber must be provided additionally.

It is an object of the invention to fashion a signal lamp of the kind stated at the outset such that light with signal colors common in motor vehicle manufacturing, including white, can be given off.

In order to achieve this object, a signal lamp of the kind stated at the outset has at least three light-emitting diodes of the colors red, blue, green, or yellow combined into each joint light source, which light-emitting diodes are arranged as close together as possible and are laid out such that the light jointly radiated from the light-emitting diodes of the colors red and green or red and yellow when voltage is simultaneously imposed on them corresponds to the color

complementary to the blue or blue-green of the third light-emitting diode, and assigned to each of these combined light sources are optical elements that mix the various colors radiated by the light-emitting diodes to form a signal color of homogeneous appearance or white. This design makes it possible to construct motor vehicle signal lamps exclusively from light-emitting diodes in simple fashion, the function of a backup light also being assumable by the light-emitting diodes.

It is desirable if the light given off by the light-emitting diodes of the colors red, green, and blue corresponds approximately to the red, green, and blue reference stimuli, so that additive color mixing makes it possible to implement nearly all colors occurring in the visible spectrum, but at least the colors common in motor vehicle lamps, including white.

Advantageous developments of the invention are characterized in the dependent Claims; the features of Claim 2 offer the advantage that white light can be achieved in very simple fashion by mixing of these colors. The features of Claims 1 to 5 have the advantage that a very simple possibility of implementation exists in which commercially available light-emitting diodes can be used and employed according to the invention.

In what follows, the invention will be explained with reference to exemplary embodiments depicted in the Drawings, in which:

Figure 1 is a schematic view of the interior of a motor vehicle signal lamp populated with light-emitting diodes according to the invention,

Figure 2 is a partial depiction of a section along the line II-II through Figure 1 in the completed signal lamp,

Figure 3 shows a detail of the arrangement of light-emitting diodes in the signal lamp of Figure 1 and Figure 2,

Figure 4 is an enlarged partial section through two of the light-emitting diodes of the signal lamp of Figure 1 and Figure 2 in a section along the line IV-IV through Figure 3,

Figure 5 is a depiction of the chromaticity diagram with reference stimuli and the actual color locations of LEDs on the market indicated,

Figure 6 shows another embodiment of a signal lamp according to the invention in which, however, there is a multichamber arrangement, and

Figure 7 shows a partial section through an exemplary embodiment in which reflectors are assigned to the individual LEDs.

Figure 1 to Figure 4 show a one-chamber signal lamp made up of a housing (1) open at the front and having a board (2) inserted and light sources (3) arranged thereon, as well as of an optical arrangement (4) set in front of light sources (3) and a face plate (5) closing the front of housing (1). As Figure 1 and especially Figure 2 show, light sources (3) are each made up of a group of three light-emitting diodes (6, 7, 8) which are arranged close together such that each lies at the vertex of an equilateral triangle. The three light-emitting diodes (6, 7, 8) therefore form in this arrangement light sources (3) and (3') respectively, which are arranged next to each other on a board (2) in the interior of housing (1) such that triangular light sources (3) and (3') respectively are located close to each other and in a sort of honeycomb pattern relative to each other, the question whether the sequence of light-

emitting diodes arranged in light sources (3) and (3') respectively is the same in the sense of clockwise or counterclockwise being of no consequence. What is crucial is that each of light sources (3, 3') exhibits a green light-emitting diode (6), a blue light-emitting diode (7), and a red light-emitting diode (8), whose color locations are indicated in the depiction of Figure 5. The color locations indicated there correspond to commercially available light-emitting diodes. Board (2), on which light sources (3) and (3') respectively are arranged in the fashion just mentioned, has a circuit for supplying current to light-emitting diodes (6, 7, 8), which circuit connects the terminals (9) of light-emitting diodes (6, 8) in each case such that the imposition of voltage on light-emitting diodes (6, 7, 8) can take place individually or jointly as selected, as will be explained with reference to Figure.<sup>1</sup>

Figure 2 and Figure 4 show that light-emitting diodes (6, 8) and (7) respectively each equipped with condensing lenses (10) have been used in the exemplary embodiment, which condensing lenses are each arranged in front of light-discharging surfaces (11), and that there are conical lenses (12) a suitable distance in front of each of these condensing lenses, which conical lenses are fashioned such that they are each assigned to three light-emitting diodes (6, 7) and (8) respectively of one light source (3). In the exemplary embodiment, all conical lenses (12) form part of a joint optical plate, which is set in front of board (2) and light-emitting diodes (6),

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<sup>1</sup> Translator's Note: The original text does not identify the figure by number.

7) and (8) respectively in such a way that the light rays discharged by individual light-emitting diodes (6, 7) and (8) respectively are mixed. In the exemplary embodiment, face plate (5) is provided with dispersing lenses (13) in such a way that the light rays coming from the conical lenses or conical prisms are perceived by an observer as a homogeneous light, even if not all three light-emitting diodes but only one or two are supplied with current and initially giving off colored light.

Naturally it is also possible to provide light-emitting diodes (6', 7', 8') without condensing lenses, as is depicted in Figure 7. These light-emitting diodes (6', 7', 8') are arranged in a reflector plate (30) such that a reflector (31) is assigned to each light-emitting diode (6', 7', 8'). Here light-emitting diodes (6', 7', 8') arranged on board (2') each lie in the center of a reflector (31).

In order that a light in the desired color be given off in dependence on the supply of current to light sources (3) and (3') respectively, the invention makes use of the additive mixing of the light of these light-emitting diodes. Figure 5 shows, in the so-called chromaticity diagram, the so-called spectrum locus (14), which comprehends the color locations of all spectral colors plotted with X as ordinate and Y as abscissa.<sup>2</sup> This continuous locus (14) is open at the ends of the spectrum. To use spectrum locus (14), one draws a straight line connecting the color locations of the ends of the spectrum. This line (15) is called the purple boundary because it contains the mixing colors from the two ends of the spectrum, namely red and blue-violet. The area bounded by locus (14) and purple boundary (15) contains the color locations of all color stimuli that can be generated.

The reference stimuli of the colors green, red, and blue are indicated in the plot of Figure 5, the red reference stimulus exhibiting a

wavelength of  $\lambda = 700$  nm, the green reference stimulus one of 546.1 nm, and the blue reference stimulus one of 435.8 nm. It is well known that all colors that occur can be represented by additive mixing of these reference stimuli.

Also, however, the color locations of commercially available light-emitting diodes are indicated in Figure 5, which color locations exhibit a wavelength of  $\lambda_{\text{peak}} = 635$  nm to 660 nm for red, one of 565 nm for green, and one of 480 nm for blue. As will be discussed later, yellow light-emitting diodes with  $\lambda_{\text{peak}} = 583$  to 590 nm are also available. The reference stimuli are identified in Figure 5 by the reference characters (16) for blue, (17) for green, and (18) for red, while the color locations of the available light-emitting diodes (6, 7, 8) are identified by (19) for blue, (20) for green, (21) for red, and (22) for yellow. It can immediately be seen that by mixing of the colored light given off by green LED (6) with color location (20) and of red LED (8) with color location (21), the color location of the color yellow can be attained at the midpoint between the two points (20, 21) on spectrum locus (14), so that light sources (3, 3') shown in Figure 1 to Figure 4 generate red light if only red LED (8) with color location (21) is energized, while on the other hand the light sources generate yellow light if red LED (8) with color location (21) and green LED (6) with color location (20) are energized. It can also be seen from Figure 5 that the yellow light (22) achieved by mixing of the light of LEDs (6, 8) with color locations (20, 21) corresponds roughly to the color complementary to blue LED (7) with color location (19) in Figure 5, so that a white light adequate for the white required for motor vehicle lamps can be generated if all three light-emitting diodes (6, 7, 8 in Figure 1 and Figure 3) are energized.

<sup>2</sup> Translator's Note: The German-language text is clear, but the figure itself shows X as abscissa and Y as ordinate.

As will immediately be clear, it would be advantageous to use LEDs that approximate the reference stimuli as far as possible. Comparison of the wavelengths from Figure 5, however, shows that the motor vehicle signal colors red (taillight, brake light, rear fog light), yellow (turn signal light, side clearance light), and white (backup light, sidelight) can be generated with certainty even if there are substantial differences between the actual colors of the available light-emitting diodes and the reference stimuli.

It is therefore possible with the invention to manufacture a lamp that looks completely colorless, that is, neutral and hence appropriate for any vehicle color, when turned off and that further exhibits, besides color neutrality, the advantage of an extremely flat structure in comparison with conventional incandescent lamps, also being adaptable to and capable of following a curved contour of a vehicle body while maintaining its flat shape. Nevertheless, by appropriately wiring up light sources (3, 3') and supplying them with current, it is possible to implement all motor vehicle signal colors including white. The lamps of Figure 1 to Figure 4 therefore can assume all necessary signal functions in motor vehicle manufacturing through appropriate wiring up and supplying with current. What is decisive is that the individually radiated colors are combined by mixing optics in such a way that only the mixing color can be perceived by the eye, that is, resolution into single colors is no longer possible.

As has already been pointed out, it is also possible to provide light sources (3, 3') made up not only of light-emitting diodes (6, 7, 8) of the three colors yellow, red, green, but also to provide four light-emitting diodes in the colors yellow, red, green, and blue, which light-emitting diodes are combined in sets of four to form a light source and are coupled with mixing optics. With suitable circuitry and current supply it is also then possible to achieve the color combinations described. Naturally, it is also possible, if the need exists, to energize only the

blue light-emitting diode and thus generate the blue light reserved for police vehicles.

Figure 6 shows a possibility for the fashioning of a motor vehicle signal lamp that is subdivided into various fields in a manner known per se for various signal functions. In this case only yellow light-emitting diodes are arranged in field (24) corresponding to the turn signal light, only red light-emitting diodes in field (25) corresponding to the taillight or brake light, light sources (3 and 3') respectively) in the composition discussed above in region (26) for the backup light, and only red light-emitting diodes for the operation of a rear fog light in field (27). In addition, a rear reflector (28) is present here. It is also possible, as is indicated in Figure 1, to populate the whole field of a signal lamp with multi-element light sources (3, 3'). It is then possible to utilize the entire field for just one function at a time, for example as backup light. In order to satisfy legislative provisions concerning overlapping actions in spite of this fashioning, provision is then made for having light sources (3, 3') driven via a processor. This processor, which is connected to transmitters and sensors, then drives light sources (3, 3') in such a way that overlaps are prevented; for example,

the entire field is resolved into individual fields if for example a brake signal and/or a turn signal are needed in addition.

### Claims

1. A signal lamp (especially a multichamber signal lamp for motor vehicles) having light-emitting diodes or light-emitting diode chips as the light source for generating at least two differently colored lamp functions and/or signal functions, on which voltage can be imposed separately or jointly as selected, characterized in that at least three light-emitting diodes (6, 7, 8) in the colors red, blue, and green or yellow are combined into a joint light source (3, 3'), the light-emitting diodes being arranged as close together as possible and laid out such that the light jointly radiated from the light-emitting diodes (6, 7, 8) of the colors red and green or red and yellow when voltage is simultaneously imposed on them corresponds to the color complementary to the blue or blue-green of the third light-emitting diode (7), and in that, assigned to each of these combined light sources (3, 3'), are optical elements (4, 5) that mix the various colors radiated by the light-emitting diodes (6, 7, 8) to form a signal color of homogeneous appearance or white.

2. Signal lamp according to Claim 1, characterized in that the wavelengths of the light-emitting diodes (6, 7, 8) correspond approximately to the reference stimuli of the colors red, green, and blue.

3. Signal lamp according to Claim 1, characterized in that the three light-emitting diodes (6, 7, 8) are arranged at the vertices of an equilateral triangle, which forms the light sources (3, 3').

4. Signal lamp according to one of Claims 1 to 3, characterized in that a reflector (3') is assigned to each light-emitting diode (6', 7', 8') of a light source (3, 3').

5. Signal lamp according to one of Claims 1 to 3, characterized in that each of the light-emitting diodes (6, 7, 8) is provided with a condensing lens (10) situated in front of the luminous surface (11).

6. Signal lamp according to one of Claims 1 to 5, characterized in that mixing optics (12) and a dispersing plate (5) are assigned to each of the light sources (3, 3') made up of three light-emitting diodes (6, 7, 8).

7. Signal lamp according to Claim 6, characterized in that the dispersing plate (5) forms the face plate of the signal lamp.

8. Signal lamp according to one of Claims 1 to 7, characterized in that the light-emitting diodes (6, 7, 8) are arranged on a board (2) that is provided with a specified circuit.

9. Signal lamp according to one of Claims 1 to 8, characterized in that the board (2, 2') including the package (1), mixing optics (12) and dispersing plate (5) are adapted to a curved vehicle contour.

Attached: 3 page(s) of Drawings

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[Header on each page of Drawings]

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[Callouts in Figure 5]

<i>blau</i>	blue
<i>weiß</i>	white
<i>gelb</i>	yellow
<i>rot</i>	red